A NEW METHOD
OF
TESTING REINFORCED CONCRETE SLABS

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A NEW METHOD

for

TESTING REINFORCED CONCRETE SLABS.

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I. INTRODUCTION

1. PRELIMINARY. - Numerous tests have been made on reinforced concrete floor slabs, but the majority of them were conducted to demonstrate the safety of a particular design. Very few have had the aim of securing data for the formulating of some general and rational method of design. In consequence, very little is known in regard to the theory of this very important element of reinforced concrete building construction. Designers are generally guided by their judgment gained from their own experience and those of others, and use the existing theories, so-called, merely as a check in their work.

The objections to the tests usually made are: first, the condition of a uniformly distributed load has not been attained as required for a basis of design; and second, accurate measurements of increments of loading, necessary for the establishment of a relation between the loads and resulting stresses, has never been made. As far as is known, all tests heretofore conducted have consisted in the piling of weights such as pig-iron, sand in bags or loose, and similar weights all of which offer more or less support to each other and thereby cause an indeterminate element in the distribution and intensity of loading upon the slab. Moreover the accurate measurement of the increments of loading is impossible. Such conditions preclude the establishment of any theory for the design of

reinforced concrete slab construction.

The object of this thesis is primarily to show the adaptibility of a hydraulic machine for the testing of slabs. It is believed that the machine used and described in the following pages removes the undesirable conditions mentioned above, and because of its cheapness, simplicity and ease of manipulation may be of some value. The number of slabs tested was restricted by the size of the room available for making, storing and testing the specimens, and by the time required to desi n the apparatus, make the slabs and perform the experiment. It being undesirable to install a crane or hoist, the size of the slabs was determined by the weight that could be readily moved and lifted with crow-bars and levers. Accordingly, only a few slabs have been tested and insufficient data is at hand for a proper comparison and conclusion. It is hoped that the difficulties encountered in the conduct of the test and discussed in the following pages, may be of some service.

2. SCOPE OF THESIS. - Six slabs of varying amounts and methods of reinforcement were tested. Eight slabs had been made, comprising four different sets, but owing to accidental failures the test data for six slabs only was secured. The four sets of slabs were: (1(Steel placed 4" center to center along short span; (2) Steel placed 4" center to center along long span; (3) Steel placed 4" center to center placed along both short and

long span combined; (4) Steel along both spans placed 8" center to center. The slabs were 3" thick and had dimensions of 3 1/2 ft. by 5 ft. They were made of a 1:2:4 mixture reinforced by 5/16" plain round rods of medium steel placed 1/2" from the surface. The age of the slabs varied from five to six months when tested.

Deflections and extensions at the center point of the slabs were taken in a continuous set of readings up to the breaking load. The extensions were determined at center of slab and from this data the unit deformation per load on a square foot of slab was calculated. An attempt has been made to calculate the unit stresses by the application of Prof. Talbot's beam formulae and the calculated unit deformations corresponding have been compared with the observed deformations. Since the extensometer has been calibrated by an indirect method, it is believed that its readings should be multiplied by some constant, and accordingly a constant relation should hold between the observed and calculated values of the deformations. Curves have been plotted which show the relation that does exist. Deflection curves have also been plotted. The action of the slabs under varying loads and the method of failure were observed. Besides the collection of the above data, the behavior of the machine and the difficulties encountered have been noted; and from this experience a discussion of a properly designed machine and various suggestions follow.

3. ACKNOWLEDGMENTS. - The tests were performed in a special laboratory provided by Armour Institute of Technology, and the work was made possible by the financial assistance of the department of civil engineering. Acknowledgment is due Prof. Phillips and Prof. Wells for assistance and encouragement, to Prof. Wilcox for advice with regard to the extensometer used, to Mr. W. F. Dietzsch for valuable suggestions, and to Mrs. Julia Beveridge for furnishing references.

II. MATERIALS, TEST PIECES, THE MACHINE AND METHOD OF TESTING.

4. STONE. - The stone used was a rather soft limestone and was ordered to pass through a 3/4" screen and over a 1/4" screen. It contained, however, a considerable amount of dust and small stones. The percentage of voids was determined by tests to be 44.5% and the weight of the stone was found to be 85 lbs. per cu. ft.

5. SAND. - A good quality of graded and clean torpedoe sand was used. The percentage of voids was determined as 30.1%. The sand weighed 101 lbs. per cu.ft.

6. CEMENT. - The Owl Cement manufactured by the German-American Portland Cement Co. was used. The results of tests on standard briquettes of neat and 1:3 mortar are given in Table I.

7. CONCRETE. - The concrete was made by the writers of this thesis. A 1:2:4 mixture was made, the materials being proportioned by a bottomless measuring box. The cement and sand were mixed thoroughly while dry and then water was added until a stiff mortar was formed. The stone which had previously been wetted was then added and the entire mass was turned over with the shovels about four or five times. Water was slowly added while mixing until a rather wet mixture was attained. Table II gives the compressive strength of the various batches of concrete mixed. The concrete weighed 148 lbs. per cu. ft.

8. STEEL. - The steel used was rather soft and ductile. The percentage of elongation was determined as 22. The value of the yield point was 50617.# Plain round rods of 5/16" diameter were used exclusively. Table III gives the values of the tension tests on the steel used.

9. FORMS. - The forms consisted simply of bottomless boxes made of 2" x 3" pieces. Two iron rods at the ends and a notched 2" x 4" at the center prevented the form from bulging upon depositing of concrete. Plate I shows the construction of the forms.

10. SLABS. - As already indicated, eight slabs were made, each being 3" thick, 3 1/2 ft. wide and 5 ft. long. Table IV gives all slabs that were made and shows the amount and method of reinforcement, date of make and degree of wettness of concrete.

The slabs were made directly upon the cement floor with the aid of the bottomless forms, the cement floor having been oiled and then covered with well greased paper. Strips of wood 1/2" x 3/4" in section were placed at the end of the span where needed to support the reinforcement 1/2" from the surface. To lessen the sag, stiff 1:3 mortar was placed under the steel rods to a thickness of about 1/2". No difficulties were encountered in placing the reinforcement loose and unsupported except at the ends. Concrete was then spread in one layer in the forms and thoroughly tamped, until water flushed to the surface, especial care being taken to prevent displacement of the steel rods. Special attention was given to secure an absolutely smooth concrete surface, and that the four corners of the slab were in one plane. Much depends upon securing this condition for a successful conduct of the tests as will be discussed later.

11. STORAGE OF SLABS. - The concrete slabs were left in the position as made until the beginning of the tests, when the forms were removed and the slabs placed in stacks. During the first few weeks the slabs were kept continually wet, but later they were wetted occasionally only, rapid evaporation being retarded by a covering of wet sand.

12. TESTING MACHINE. - Plate II shows the plan, end and side view of the machine used, and illustrates the slab in position. The machine, which was built in the shops

of Armour Institute of Technology, consists simply of a watertight wooden platform (B) having four sills (S) placed along its edges upon which the slab (A) rests, a watertight line of contact between the sills and slab being secured by piston packing (P) compressed by the use of clamps (C) as indicated. The shallow watertight compartment thus formed between the platform and slab holds water under a "head" which exerts a uniform upward pressure against the slab. The iron pipe (D) which enters the compartment through the bottom of the platform is attached to a hose (H) having a reservoir (R) at its end that can be raised or lowered by use of rope and pulleys according to the pressure desired. A mercury manometer (M) measures the pressure against the slab in pounds per square foot.

Plate III shows the machine in section with the slab in position, and illustrates its construction. The platform is 6" thick, 3 1/2 ft. wide and 5 ft. long, the same as that of the slabs, and was constructed of a selected quality of white pine lumber. The six inches of thickness were secured by three layers of 2" x 6" planking securely held together by wood screws. In the bottom and upper layers, the lengths of the planks were placed along the short span and the intermediate layer along the long span. The upper surface of the platform was made as near watertight as possible by calking the grooves in the joints with hemp and by covering the entire surface with about

1/2" of roofing tar. The sills securely screwed to the platform alongs its four edges were 3/4" high at the center and 3" wide, its center being 3" from the edge of the platform as indicated. The joints of the sills at the four corners were thoroughly calked with hemp and their entire surface was also covered with tar. One length of 1/2" Eureka piston packing, spliced as indicated in the drawing, was placed upon the center of the sills. The slab, resting upon this packing with its edges coinciding with those of the platform, was firmly clamped to the platform by 18 clamps, as shown in the drawing.

The mercury manometer was an ordinary U tube, made by connecting two glass tubes with a piece of rubber tubing covered with adhesive tape, and placed against a special graduated scale which gave the pressures directly in pounds per square foot.

13. EXTENSOMETER. - The upper side of the slab being a plane surface without any projections, it was impossible to use a commercial extensometer to measure deformations. An instrument that could be read at any instant was desirable. In searching for an extensometer to satisfy these requirements a diagram was found of one devised by Mr. Walter C. Durfee of Harvard University. The principle was adopted and Plate IV is the design of the instrument, which was constructed in the shops of Armour Institute of Technology.

It is a bar with a pointed stud (a) and a roller (b). The stud anchors the instrument so that a deformation of the material under the extensometer causes a rotation of the roller. The roller carries a flat circular glass plate (c) so placed that its upper surface intersects the center-line of the roller. On this plate rests a lens (d) with a radius of curvature of 160 inches, mounted on a lever (e). A movement of the roller changes the point of contact, there being a cam-like action by the plate and lens. The interference of light phenomenon, known as Newton's rings, indicates the position of the contact point. Graduations on the lens determined the movement of the point. To calibrate the instrument a lever was attached to the roller and a micrometer was placed 10 inches from the center of the roller as shown in (f). The movement of the rings corresponding to a definite micrometer reading was noted for all divisions of the scale. A calibration curve has been plotted. The average ratio between extensometer reading and actual extension was used.

14. METHOD OF TESTING. - The steel rods and the 1" cubes were tested on the 60000# Olsen machine, the 6" concrete cubes on the 200000# Riehle machine, the briguettes on the Fairbanks machine, while the slabs were tested on the machine shown in Plates II and III.

The slabs weighed about 650# each and were moved to and from the machine by means of crow bars and rollers.

After the packing was placed, the slabs were put into position by rolling them up two 2" x 4" scantlings slanting from the machine to the floor. The steel reinforcing was on the upper size. The packing was given final adjustment and then the slabs were clamped down so as to make a water-tight fit between the slab and the machine. Any uneveness in the slab at its edges, which would be liable to cause undue leaking, was removed by the application of neat cement, which was allowed to set for several days before the test was carried out. Plaster of Paris was applied to the top of the slab so as to make the cracks more noticeable and also to form a smooth surface for the roller of the extensometer.

The center deflections were read on all slabs by means of a vertical scale (a) graduated to 64ths of an inch, and a dumpy level placed at a distance of about 12 feet from the slab. The magnifying power of the level made it possible to easily estimate to 256ths of an inch. The deformation of the upper fibre was measured by the extensometer showm in Plate IV. The extensometer was placed so as to obtain readings for both the long and the short spans of each set of slabs, but having only one instrument its position was changed in testing similar slabs and one set of readings of each kind was obtained.

It was found that three men were necessary to conveniently carry out the tests. One man at the level

to read deflections, one at the rope to vary the load and read the mercury column, and one at the extensometer to read the extensions and to make note of the appearance of cracks. The first step in the actual performance of the test was to obtain zero readings of the extensometer and deflection scale when the mercury column registered no load. There is a slight error introduced into these zero readings and consequently into all subsequent readings, which is negligible. This error is due to the position of the mercury column, because when it denotes no pressure there really exists a pressure on the slab in inches of water, equal to the difference in elevation between the bottom of the slab and the contact plane of the water and the mercury in the mercury column. The pressure on the slab was increased by slowly raising the reservoir, and at increments of from 100# per square foot to 200# per square foot, readings were taken.

With several of the slabs considerable difficulty was experienced due to excessive leaking between the slab and the packing. This was particularly true under the greater pressures, in which case there was also a tendency to force the packing out of place. When these extreme leaks occurred the reservoir emptied quickly, causing a drop in the head and a consequent lowering of the pressure. Under such circumstances the leaks were stopped by driving the packing in tightly between the

machine and the slab, using a flat piece of steel with rounded edges. The reservoir was refilled and the test continued up to the point of failure. Although the machine was not absolutely water-tight, any ordinary small leak was taken care of by the supply in the reservoir without causing a fall in the pressure.

III. EXPERIMENTAL DATA & DISCUSSION.

15. DISCUSSION OF MACHINE. - The performance of the testing machine was satisfactory and no serious difficulties were encountered. The machine lacked perfection in some details, causing inconveniences that might have been avoided.

To design a platform that would withstand the repeated loading necessary to break the eight slabs, was a problem.of some uncertainty, because the strength of the slabs when supported on four sides was an unknown quantity. The thickness of the platform (six inches) was designed, approximately, with a large factor of safety, and it was found that the platform was in good condition at the termination of the tests. The attainment of a water-tight surface presented some difficulties. It seemed impossible to make the platform absolutely impervious, therefore it was decided to use a small reservoir so as to replenish the loss due to these unavoidable leaks. A constant "head" was thus maintained. In this platform all joints exposed to the water had grooves cut 1/4" wide and 1 1/2" deep which were thoroughly calked

with jute. The entire surface was covered with roofing tar to a depth of 1/2". Experience showed that too great care can not be taken in water-proofing the surface.

The number, size and spacing of the clamps which took the reactions of the slab and also firmly gripped the slab to the platform was determined as accurately as possible. It was found however that the clamps were sprung slightly out of shape at the end of the tests. This was due chiefly to overstressing the clamps in placing them.

The use of a reel with a ratchet would facilitate the work of raising and lowering the reservoir. It was also found that a sliding scale for the mercury column would aid the observer in making rapid readings.

The highest recorded load was 1900# per sq.ft. and it was obtained with but little trouble because the slab used in this case had a smooth and plane surface. Slabs that were not made so carefully were given a coating of cement mortar at the contact surface of the packing. Under these conditions a pressure of 1000# to 1200# per sq.ft. was maintained satisfactorily, but for greater pressures leakage occurred between the slab and the mortar. The fact was brought out that in order to avoid this trouble the slab should be absolutely smooth and plane. This is a vital point to consider. As previously stated the slabs were constructed in bottomless forms placed on the cement floor which was supposed to furnish a plane

surface. However, when the slabs were to be tested, it was found that the majority did not have a plane surface. The only satisfactory method of slab construction involves the use of forms having bottoms. When the slabs are made, a coating of neat cement mortar should be spread on that part of the surface which will be in contact with the packing during the test.

Under very high pressures the behavior of the machine revealed a defect in that the packing was displaced sufficiently to cause serious leaks and a consequent rapid lowering of the pressure. A shallow groove made to receive the packing would prevent this dislodgement. If slabs of greater spans had been tested, such excessive loads would not have been necessary. This would mean fewer leaks which always cause delays and interruptions in a continuous set of readings.

16. DISCUSSION OF THEORIES. - A preliminary discussion in regard to the action of slabs or plates under either a uniform or concentrated load woüld be proper. As already indicated, no theory based upon experimental results, such as is the case for reinforced concrete beams, is in existence for reinforced concrete slabs. However, for plates of a homogeneous material, various theories have been advanced by such authorities as Bach and Grashof, as a result of their tests on steel plates supported or fixed on all sides; but they differ in that the former assumes the sections through

the diagonals as the planes of greatest stress, whereas the latter assumes the mid section parallel to the greater span as that of the greatest stress. Hence, we see that even in the case of plates made of a homogeneous material such as steel, there is a difference of opinion in regard to the magnitude of the maximum bending moment and to the position of the sections along which it acts. Besides the uncertainty as to the value of the maximum bending moment, the determination of the stresses becomes a matter of great difficulty due to their complexity. The directions of the stresses vary at all points and the effect of lateral contraction is an uncertain element.

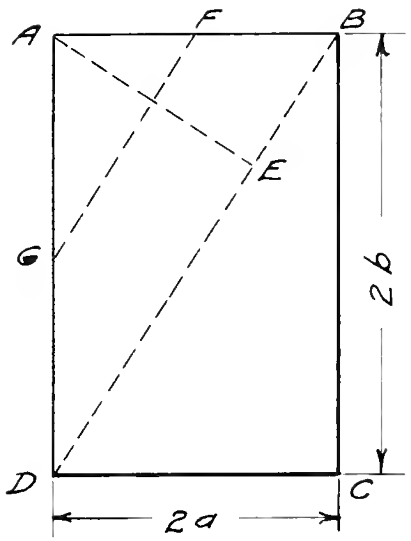
In the case of reinforced concrete slabs, this extremely difficult problem is still further complicated. The additional difficulty arises from the fact that the steel reinforcement which is placed rectangular, lies in the direction of the resultant stresses at a few points only, and accordingly the application of any reinforced concrete beam formula becomes a matter of doubtful propriety. An assumption can, however, be made that the rectangular placed steel rods take their respective components of the resultant stress, the concrete preventing any lateral movement of the rods. It would be practically impossible to attempt the determination of the stress in the steel by a method based upon the resolution of stresses, and consequently in the computations that follow the stress in the steel

has been computed with the assumption that it takes the direct tensile stress due to the maximum bending moment. The direction of the cracks in the slabs as is shown in the accompanying sketches indicate that the assumption is a reasonable one.

In regard to the compressive stresses in the concrete, still greater trouble is experienced since practically nothing is known as to the effect of lateral contraction in concrete. In computing the compressive stresses in steel plates Bach and Grashof use a constant, the coefficient of lateral contraction in their computation of the extreme fibre stresses. Because of the uncertain behavior of concrete in this respect it will be also assumed that the concrete takes the direct compressive stress, no attention being given to lateral contraction.

A reasonable formula, either empirical or rational, is desired. The formulas of Bach have been suggested as applicable to reinforced concrete slabs. Considerable objection, however, is raised to this assumption, because reinforced concrete is not a homogeneous material of equal strength in all directions. His derivation follows.

Having observed from experiment that square or nearly square plates, supported on four sides usually fracture along a diagonal, Bach derived a simple formula which gives the bending moment along this diagonal.



Let A B C D represent the slab. Draw the diagonal B D and consider the forces on the left hand side. The resultants of the reactions along A B and A D are located at the mid-points F and G respectively. Therefore the resultant of the reactions will lie on the line F G.

Let A E equal (C) and the pressure (p). The load on the portion A B D, equal to 2 p a b, acts at the center of gravity of A B D. The bending moment about the line B D equals $2\ p\ a\ b\left(\frac{c}{2} - \frac{c}{3}\right) = \frac{p\ a\ b\ c}{3}$. An objection to the application of this formula arises in determining the maximum bending moment at the center, for it does not remain constant at all points along the diagonal. The fact that a diagonal crack starts at the center travels diagonally to the supports is not proof that the maximum stresses follow the diagonal, for when a crack starts in a brittle material like concrete, very small loads will lengthenthe crack.

Another method used is to calculate the bending moment as if the slab was a simple beam on two supports and then multiply by coefficients depending on the span considered. The coefficient formula of Grashof and

Rankine is $$r = \frac{a}{a + b}, \qquad s = \frac{b}{a + b}.$$

The French government has given its engineers the formula

$$r = \frac{1}{1 + 2\frac{a}{b}}, \qquad s = \frac{1}{1 + 2\frac{b}{a}}.$$

In both formulas (a) represents the long span, (b) the short span, and (s) and (r) the coefficients which are to be used for determining the bending moment for the short and long spans respectively. The reasoning necessary to establish these formulas is not entirely satisfactory. Strips at right angles are assumed to have equal center deflections in Grashof and Rankine's forumla. These formulas can be used only when the strength of the slab to resist bending is the same in both directions.

The above formulas could be made more satisfactory by supplying constants obtained from experiments, thus giving them an empirical form. Nothing has been done to prepare such a systematic series of constants.

The distribution of reactions involves complicated analyses. Various radically different assumptions are made in regard to the magnitude of the reactions at points along the supports.

17. DISCUSSION of RESULTS of TEST. - All slabs tested were broken, but maximum loads were obtained for A1, A2, B1 and B2 only. In tables under the headings A1, A2, B1, B2, C1 and C2 are given the center deflection and extension readings for various intensities of loading. The actual deflections and the unit extensions are also given. The extensions were taken along what was thought to be the weaker span so that the maximum extensions could be measured. The extensometer was placed for each slab as indicated below:-

A1	-	extensometer	along	greater	span
A2	-	"	"	lesser	"
B1	-	"	"	lesser	"
B2	-	"	"	longer	"
C1	-	"	"	lesser	"
C2	-	"	"	lesser	"

A1 and A2 broke along longer span as was expected; but it was supposed that B1 would break along the shorter span parallel to the reinforcing, and the extensometer was placed accordingly. It failed, however, along the longer span.

An attempt to compare the observed unit deformations with the calculated deformations as determined by the application of Talbot's beam formula has been made. Since the exact value of the maximum bending moment is an unknown quantity and the application of Talbot's formula is not correct, as already discussed, no agreement between the

observed and calculated values can be expected. Grashof's formula and the expression given out by the Grench government have both been used in the calculation of the maximum bending moments. Following is given a sample calculation for the deformation on the tension side for each of the two values of bending moment.

18. SAMPLE CALCULATION. -

Average strength of concrete 3126 # per sq. in.

Percent of reinforement .807 % $\therefore p = .00807$

Ratio of Moduli of Elasticity $8.34 = e$

All symbols used same as in Talbots Formula

Coeff. of bending moment $\frac{a^4}{a^4+b^4} = .835$

$M = \frac{.835}{8} w l^2 = .104 w l^2$

Load 1000 # per sq. ft. $M = 11232$ in. lbs.

Assume $c = 1000\#$ $\frac{c}{c'} = \frac{1000}{3126} = .32$

$q = \frac{2 \pm \sqrt{4-1.28}}{2} = .175$

$k = \sqrt{.1712 + .0073} - .0856 = .3369$

Given $d = 2.375''$ $kd = .801''$

$z = \frac{.801}{3}\left(1 + \frac{.175}{4 \times 2.825}\right) = .271''$ $\therefore d - z = 2.104''$

$M = fA(d-z)$ $\therefore f = \frac{11232}{.2301 \times 2.104} = 23200\#$ per sq. in.

$\therefore \lambda_s = .00077''$

Elongation of Concrete $= \frac{2.199}{1.574} .00077 = .00107''$

French coeff $= \frac{1}{1 + \frac{2b}{a}} = .71$ $\therefore M = \frac{.71}{8} w l^2 = .089 w l^2$

Assume $d - z$ constant

$f = \frac{9610}{.2301 \times 2.104} = 19770\#$ per sq. in. $\lambda_s = .000686''$

Elongation of concrete $\frac{2.199}{1.574} .000686 = .000956''$

19. CURVES. - Extension and deflection curves have been plotted for each slab showing the relation existing between these values and the various loads.

The deformation curve for A1 is characteristic of the behavior of concrete. The yield point is reached at a load of about 1000# per sq.ft. and for slightly higher loading the concrete extends rapidly without increase of load. The curve for A2 should be similar to that of A1; it is not quite as steep, however. At a load of about 650# per sq.ft. the slab yielded without increase of load. The deflection curves for both slabs incline toward the X- axis for high loads:

The extension curves for both B1 and B2 show that the slabs yielded at a loading of about 1100# per sq.ft. The curve for B2 is somewhat steeper than that for B1, showing that the deformations were smaller for the long span. The curve for B2 again becomes steep for loadings greater than 1200# per sq.ft., and that for B1 has the same tendency. The deflections increase greatly for both slabs for loadings above 1000# per sq.ft.

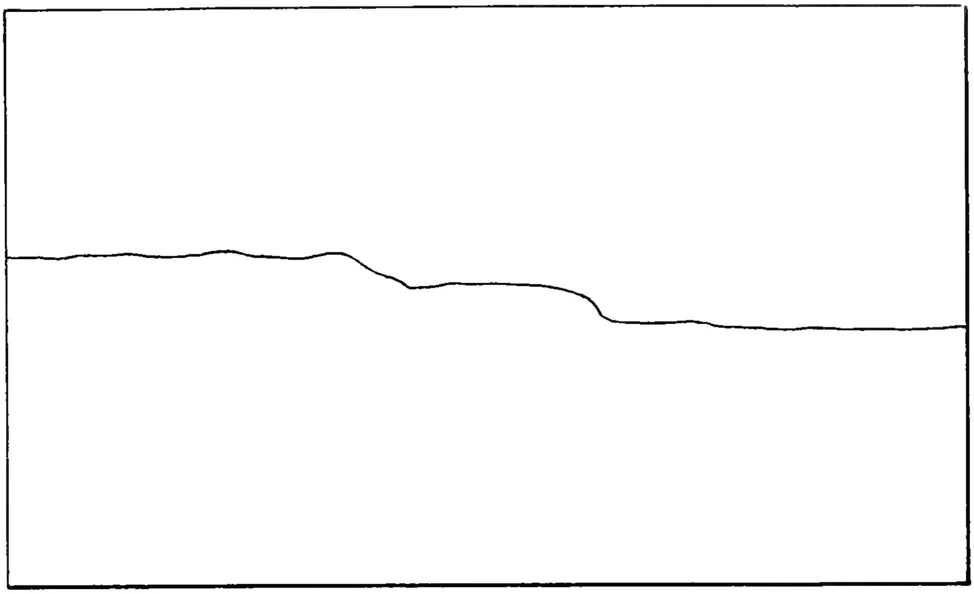
The yield point for C1 is reached at a loading of 1400# per sq.ft. and that for C2 at about 1100# per sq.ft. The effect of steel reinforcing along both spans is shown in that the ultimate rupture is greatly delayed.

20. MANNER of FAILURE. - The failures of A1 and A2 were characteristic concrete tension failures. The rupture

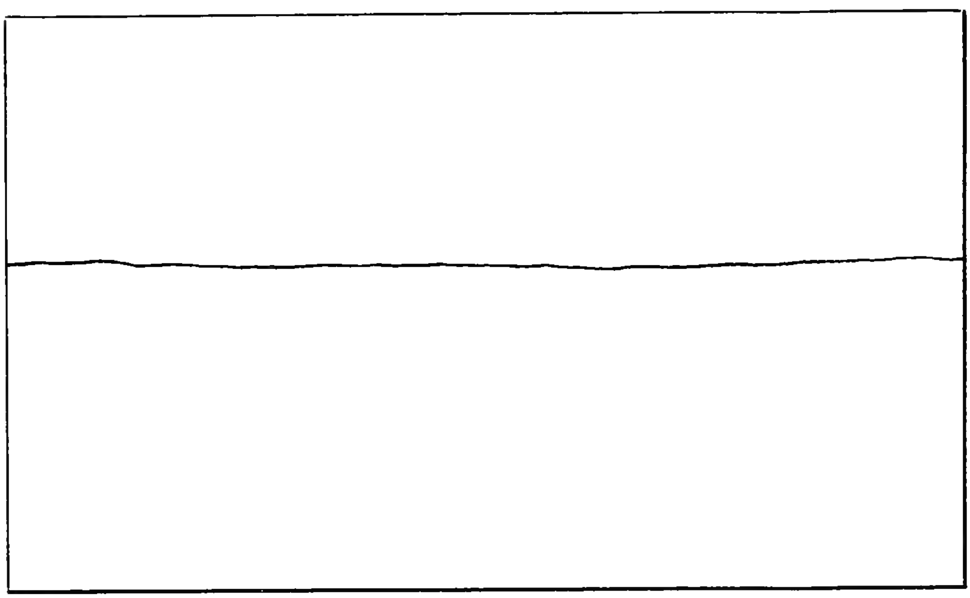
occurred suddenly without warning, the slab being broken into two equal portions by fracture through its center parallel to the longer span, as indicated in the diagrams showing cracks for A1 and A2. The nature of this failure was to be expected, since the reinforcement was placed along the longer span.

The slabs B1 and B2, with steel along the shorter span, showed a marked difference in their behavior as compared with the A series slabs. The slabs, C1 and C2, with reinforcement along both spans, behaved in a similar manner except that the ultimate loadings were somewhat greater. Failure and the position of the line of fracture were anticipated by the appearance of moisture along lines. For low pressure isolated beads of percolating water were observed on the slabs. As the pressure was increased, these beads became more numerous, and determined the position of the fracture line. No cracks could be detected upon the first indication of moisture; but, when a moisture line was established, very fine hair cracks could be seen. Upon rupture the water welled out, and the slabs closed up, the cracks still being noticeable. It is believed that the actual ultimate failure did not occur for these four slabs, but that some value very close to the ultimate value was reached. The calculations for the compressive stress in the concrete and the tensile stress in the steel indicate that the

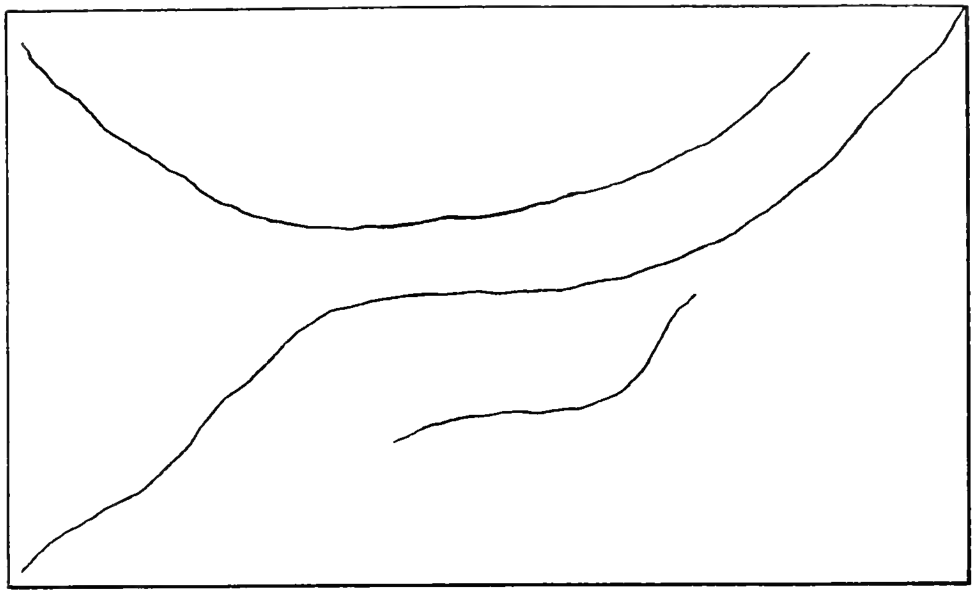
ultimate strength for both was not reached. Partial failures, however, occurred for all slabs at about 1000# to 1300# per sq.ft. where the concrete broke in tension. All deformation curves show this similarity, indicating clearly that a partial failure occurred for concrete in tension. It was impossible to examine the compression side of the slabs after failure without disturbing the condition of the slabs as left at the end of the test. Accordingly no information was obtained as to the appearance of the slabs on the compression side. If a compression failure had occurred, it may have been evidenced by pieces of broken concrete in the machine. Such was, however, not observed. Diagrams indicate the position and number of cracks.



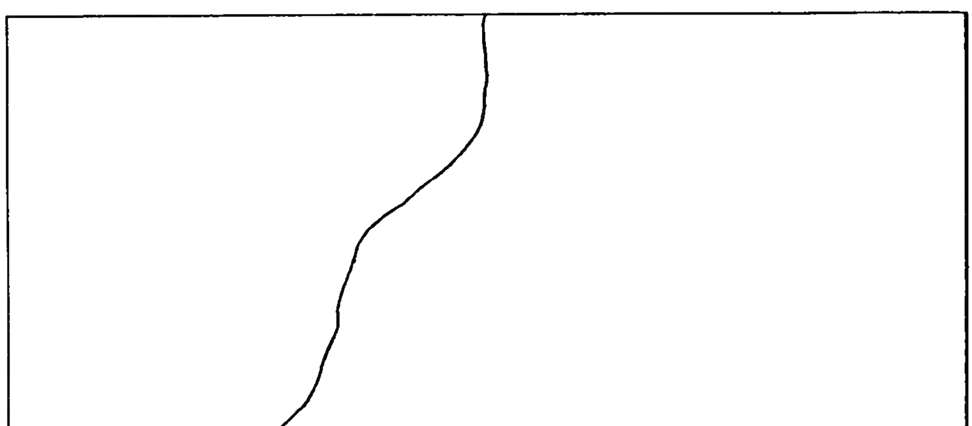
SLAB A1



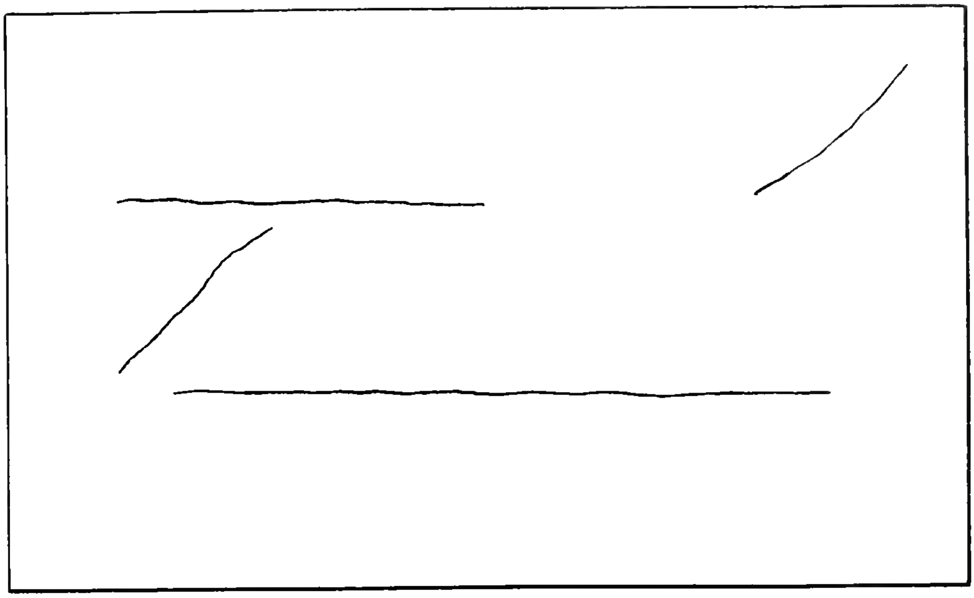
SLAB A2



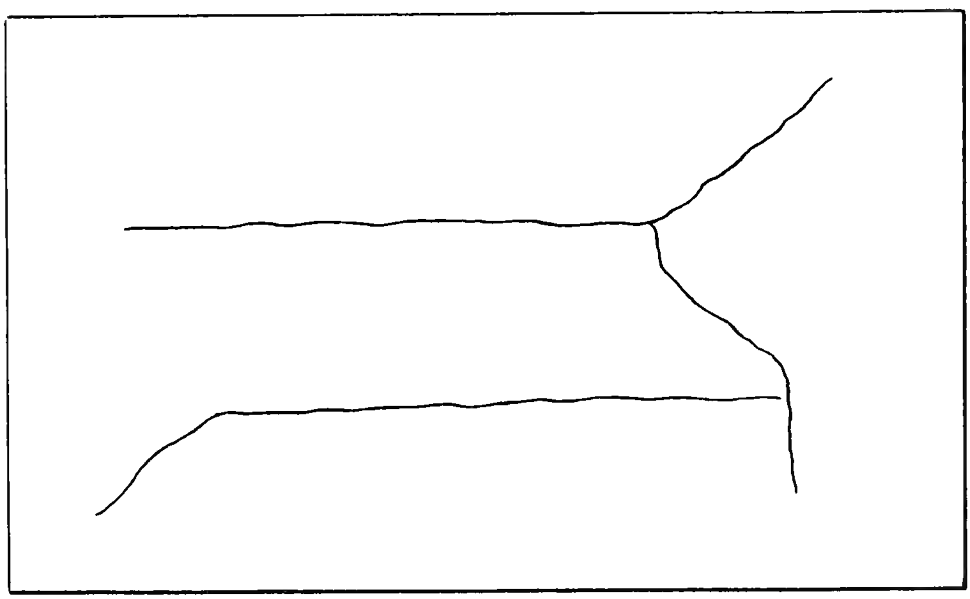
SLAB B1



SLAB B2



SLAB C1



SLAB C2

SLAB A 1				
LOAD	Deflection		Elongation	
	Reading	Actual	Reading	Actual
0	1	.0000"	.28	.000000"
450	2	.0156"	.35	.000024"
650	3	.0312"	.39	.000037"
1000	4	.0469"	.45	.000058"
1100	-		1.54	.000428"

Load recorded in lbs per sq.ft.

Deflection reading measured in 64ths. of an inch.

SLAB A 2				
LOAD	Deflection		Elongation	
	Reading	Actual	Reading	Actual
0	0	.0000"	.98	.000000"
275	$\frac{1}{2}$	.0078"	1.15	.000058"
350	$\frac{3}{4}$	.0117"	1.20	.000075"
460	1	.0156"	1.29	.000105"
575	$1\frac{1}{4}$	.0195"	1.38	.000136"
620	$1\frac{1}{2}$	.0234"	1.41	.000146"
660	$1\frac{3}{4}$	.0273"	1.56	.000197"
720	2	.0312"	1.60	.000211"
880	$2\frac{3}{4}$	.0429"	1.70	.000245"
950	3	.0469"	1.74	.000258"

Load recorded in lbs. per sq. ft.

Deflection reading measured in 64ths. of an inch.

SLAB B 1				
LOAD	Deflection		Elongation	
	Reading	Actual	Reading	Actual
0	0	.0000"	.45	.000000"
100	$\frac{1}{4}$	.0039"	.46	.000003"
200	$\frac{1}{2}$	.0078"	.47	.000006"
325	$\frac{3}{4}$	.0117"	.48	.000013"
425	$\frac{7}{8}$	.0136"	.50	.000017"
520	1	.0156"	.51	.000024"
625	$1\frac{1}{4}$	.0195"	.53	.000027"
750	$1\frac{1}{2}$	.0234"	.55	.000034"
825	$1\frac{3}{4}$	.0273"	.58	.000044"
940	2	.0312"	.60	.000051"
990	$2\frac{1}{4}$	.0352"	.61	.000054"
1075	$2\frac{1}{2}$	.0390"	.64	.000065"
1100	$2\frac{3}{4}$	.0429"	.73	.000095"
1075	4	.0625"	.98	.000182"
1100	$4\frac{1}{4}$	.0664"	1.03	.000197"
1120	$4\frac{1}{2}$	.0703"	1.24	.000269"
1200	$5\frac{1}{2}$	.0860"	1.48	.000350"
1250	$6\frac{3}{4}$	.1055"	1.54	.000371"
1320	8	.1250"	-	-
1340	$8\frac{1}{4}$	.1289"	-	-
1450	$10\frac{1}{2}$	.1640"	-	-

Load recorded in lbs. per sq. ft.

Deflection reading measured in 64ths. of an inch.

SLAB B2

LOAD	Deflection Reading	Deflection Actual	Elongation Reading	Elongation Actual
0	0	.0000"	.01	.000000"
200	1/3	.0052"	.02	.000003"
400	2/3	.0104"	.03	.000006"
600	1	.0156"	.05	.000013"
750	1 1/4	.0195"	.06	.000017"
900	1 1/2	.0234"	.07	.000020"
1000	1 3/4	.0273"	.10	.000031"
1175	2 3/4	.0429"	.56	.000187"
1250	3 1/4	.0508"	.56	.000187"
1350	5 3/4	.0898"	.56	.000187"
1450	5 3/4	.0898"	.58	.000194"
1525	6	.0938"	.61	.000204"

Load recorded in lbs. per sq. ft.
Deflection reading measured in 64ths. of an inch.

SLAB C1				
LOAD	Deflection		Elongation	
	Reading	Actual	Reading	Actual
0	0	.0000"	.26	.000000"
225	1/2	.0078"	.39	.000044"
250	3/4	.0117"	.40	.000048"
400	1 3/4	.0195"	.45	.000065"
610	2	.0312"	.55	.000099"
675	2 1/4	.0352"	.57	.000105"
760	3 1/2	.0547"	.67	.000139"
980	4	.0625"	.74	.000163"
1300	5 3/4	.0899"	.90	.000218"
1425	6 1/2	.1016"	1.03	.000262"
1400	8	.1250"	1.07	.000275"
1550	8 3/4	.1368"	1.45	.000404"
1600	10	.1562"	1.39	.000453"
1700	12	.1874"	1.85	.000541"
1750	13	.2032"	2.20	.000659"
1700	14 3/4	.2305"	2.40	.000728"

Load recorded in lbs. per sq. ft.

Deflection reading measured in 64 ths. of an inch.

SLAB C2				
LOAD	Deflection		Elongation	
	Reading	Actual	Reading	Actual
0	0	.0000"	.43	.000000"
140	1/4	.0039"	.48	.000017"
300	1/2	.0078"	.55	.000041"
425	5/8	.0097"	.60	.000058"
520	7/8	.0136"	.65	.000075"
640	1	.0156"	.72	.000099"
750	1 1/4	.0195"	.77	.000116"
850	1 3/4	.0273"	.83	.000136"
940	2	.0312"	.87	.000150"
1000	2 1/2	.0391"	.89	.000156"
1060	2 1/2	.0391"	1.00	.000194"
1125	3	.0469"	1.13	.000238"
1190	3 1/2	.0547"	1.32	.000309"
1230	3 1/2	.0547"	1.50	.000364"
1290	3 3/4	.0586"	1.58	.000391"
1350	4	.0625"	1.67	.000422"
1360	4 3/4	.0742"	2.04	.000547"
1400	4 3/4	.0742"	2.07	.000558"
1430	5	.0781"	2.13	.000578"
1475	5	.0781"	2.17	.000592"
1500	5	.0781"	2.18	.000595"
1525	5 3/4	.0898"	–	–
1575	6 1/4	.0977"	–	–

Load recorded in lbs. per sq. ft.

Deflection reading measured in 64ths. of an inch.

TABLE I

CEMENT TEST.							
7 DAYS				28 DAYS			
Compression Lbs. per sq. in.		Tension Lbs. per sq. in.		Compression Lbs. per sq. in.		Tension Lbs. per sq. in.	
Neat	1:3	Neat	1:3	Neat	1:3	Neat	1:3
6620	375	668	121	6985	430	985	157
4225	460	691	106	7830	600	968	140
6900	300	589	128	11500	455	800	143
8260	250	662	95	11960	665	750	156
6490	435	534	180	10670	470	932	148
6520	450	538	125	11560	450	875	161
8270	325	629	130	12880		940	159
6335	450	633	117	10950		826	154

TABLE II

COMPRESSION TEST OF 6" CUBES.			
Concrete as in	Age days	Crushing Load	Strength lbs per sq. in.
Slab A	163	98150	2726
" "	163	89100	2475
" "	163	117180	3255
" B	159	127000	3527
" "	159	108200	3005
" C	156	129000	3582
" "	156	127000	3527
" "	156	115250	3200
" D	156	106000	2944
" "	156	108880	3023
	AVERAGE		3126.

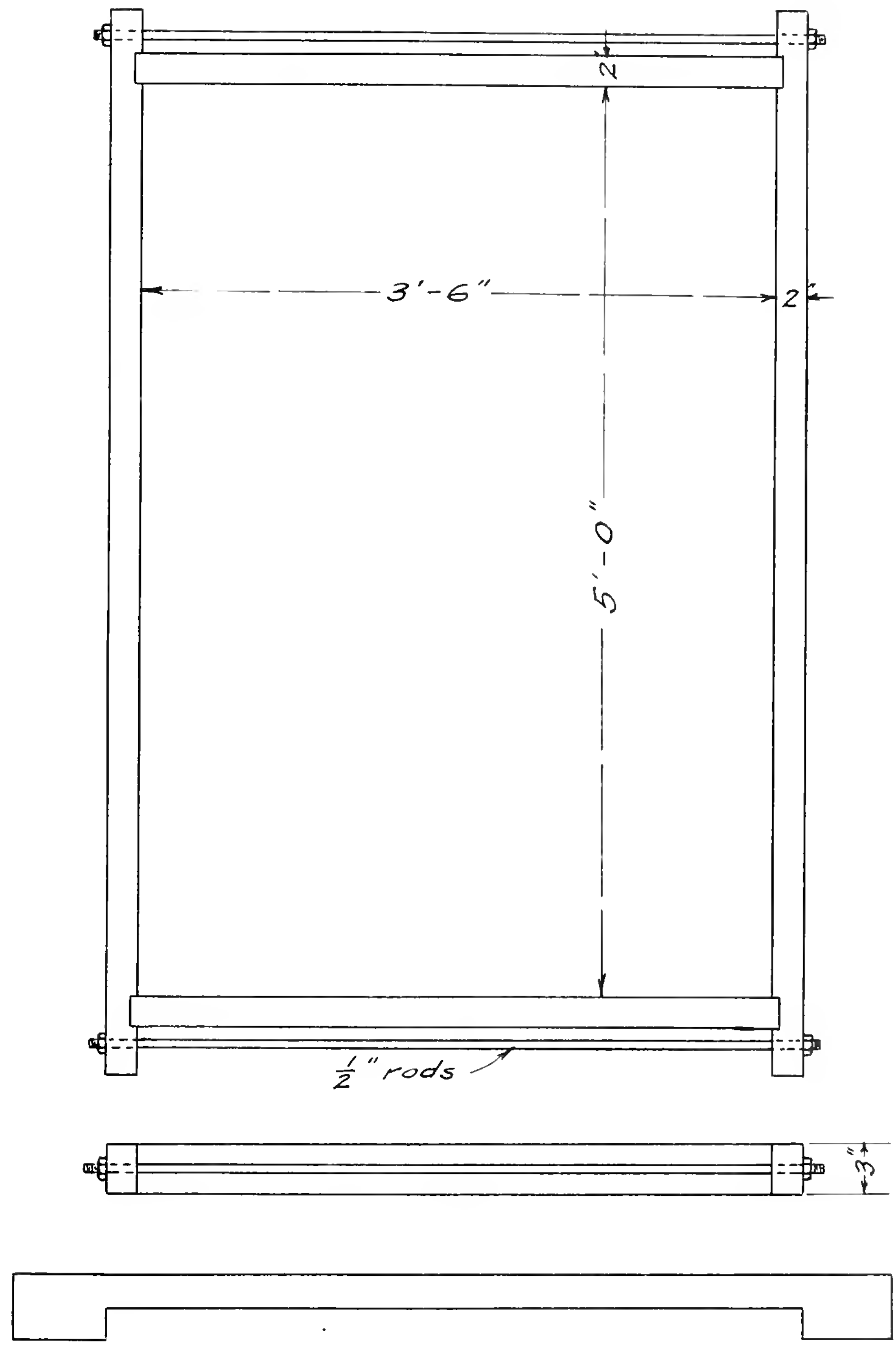
TABLE III

STEEL TEST			
Test Piece	Yield Point Lbs. per sq. in.	Tensile Strength Lbs. per sq. in.	Ductility
1	52200	63230	22 %
2	50200	64540	23 %
3	49540	64000	23 %
Average	50647	63923	22.67 %

TABLE IV

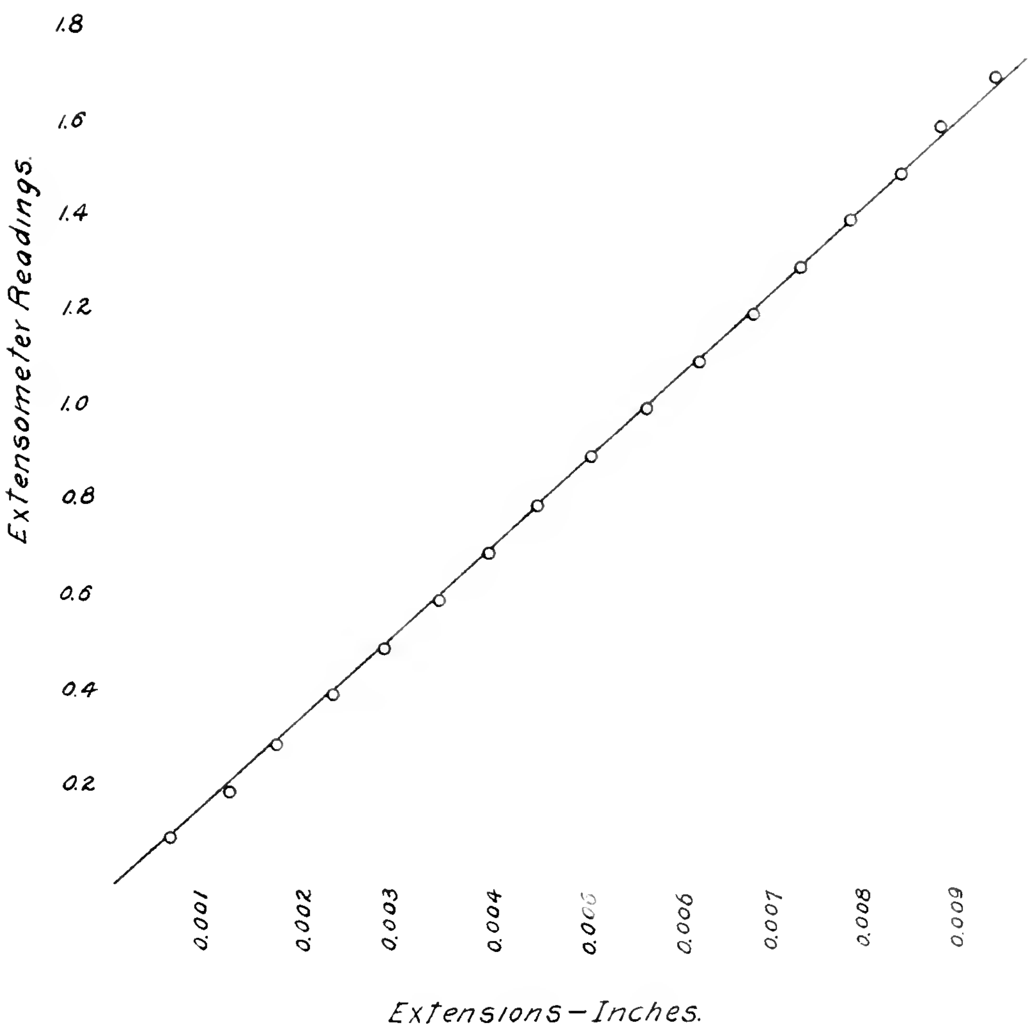
SLAB DATA			
Slab	Age	Nature of Concrete	Manner of Reinforcing
A_1	144	Medium	Long Span 4" C. to C.
A_2	147	"	"
B_1	150	Wet	Short Span 4" C. to C.
B_2	152	"	"
C_1	163	Very Wet	Both Spans 4 C. to C.
C_2	168	" "	"
D_1	170	" "	Both Spans 8" C. to C.
D_2	172	" "	"

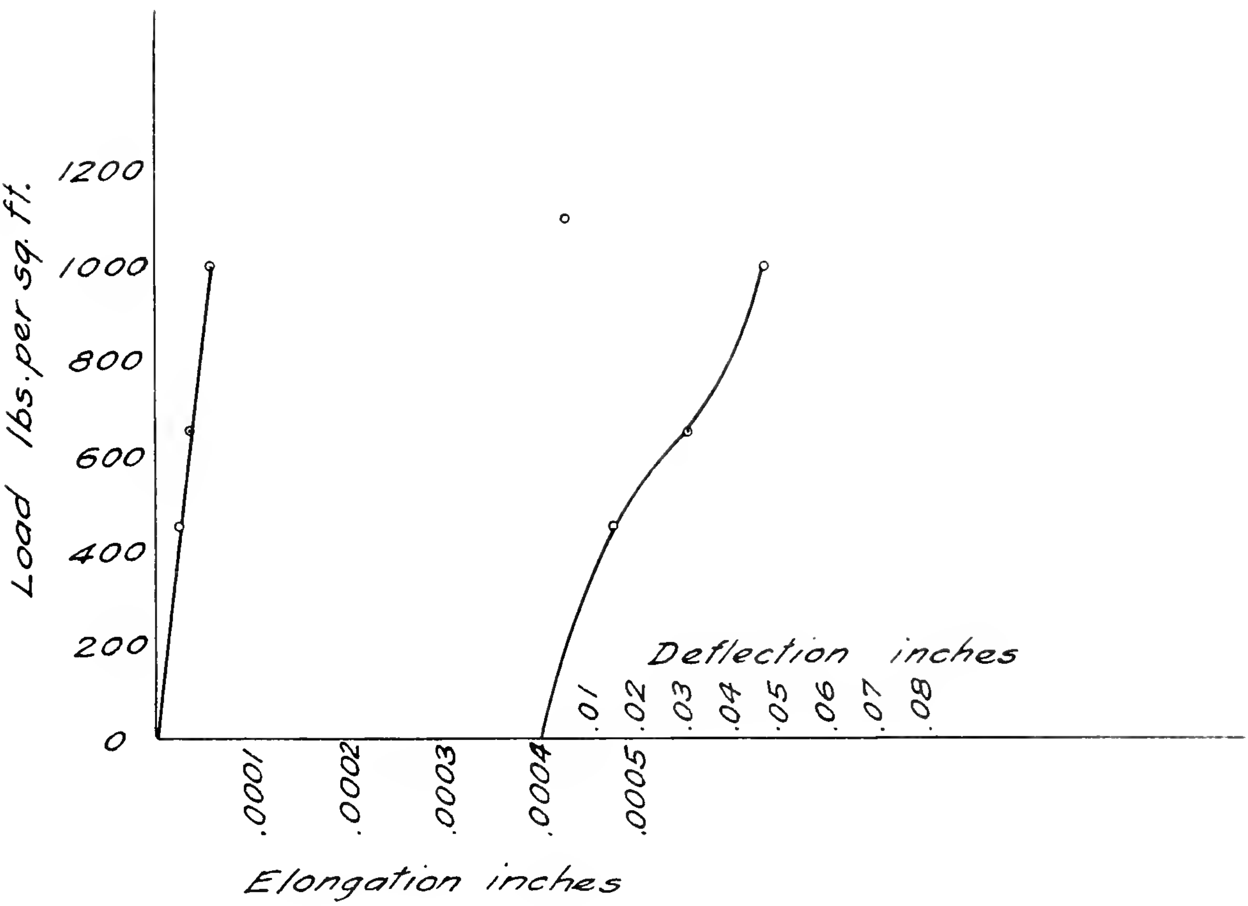
Plate I



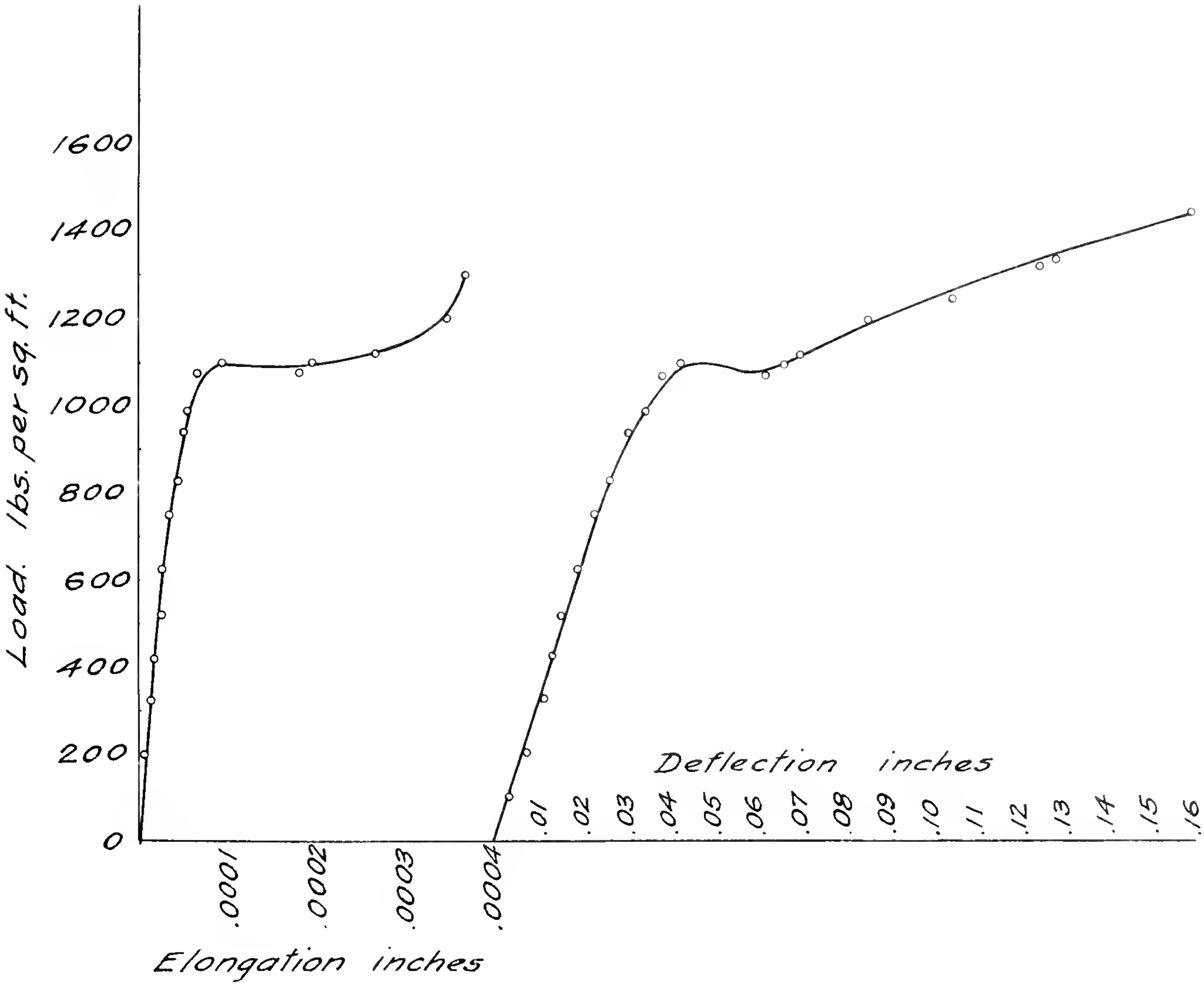
Cross Tie

Calibration Curve
of
Extensometer

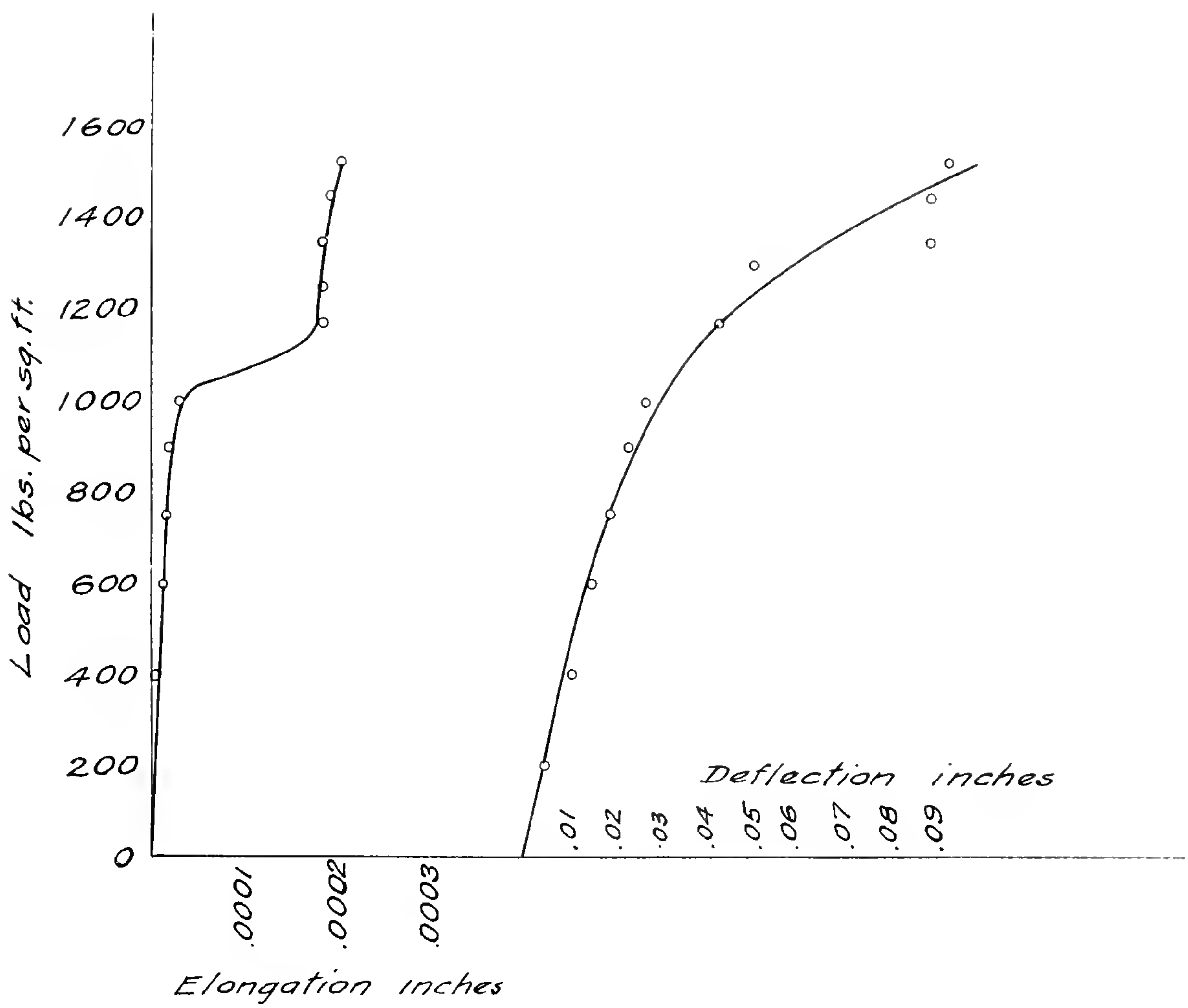



Load lbs. per sq. ft.
1200
1000
800
600
400
200
0
Deflection inches
.01
.02
.03
.04
.05
.06
.07
.08
.0001
.0002
.0003
.0004
.0005
Elongation inches

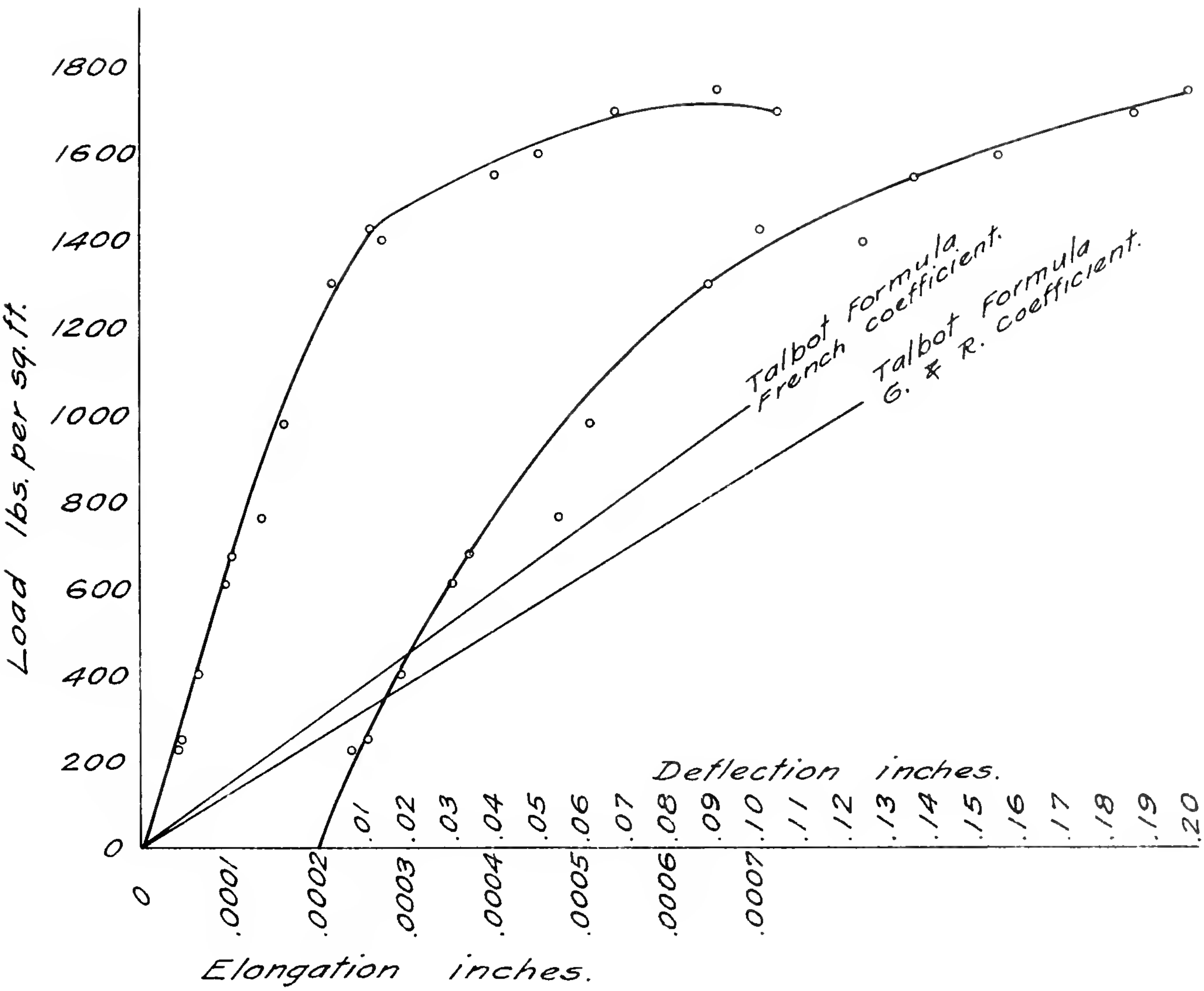
SLAB A1


Load. lbs. per sq. ft.
1600
1400
1200
1000
800
600
400
200
0
Deflection inches
.01
.02
.03
.04
.05
.06
.07
.08
.09
.10
.11
.12
.13
.14
.15
.16
.0001
.0002
.0003
.0004
Elongation inches

SLAB B1

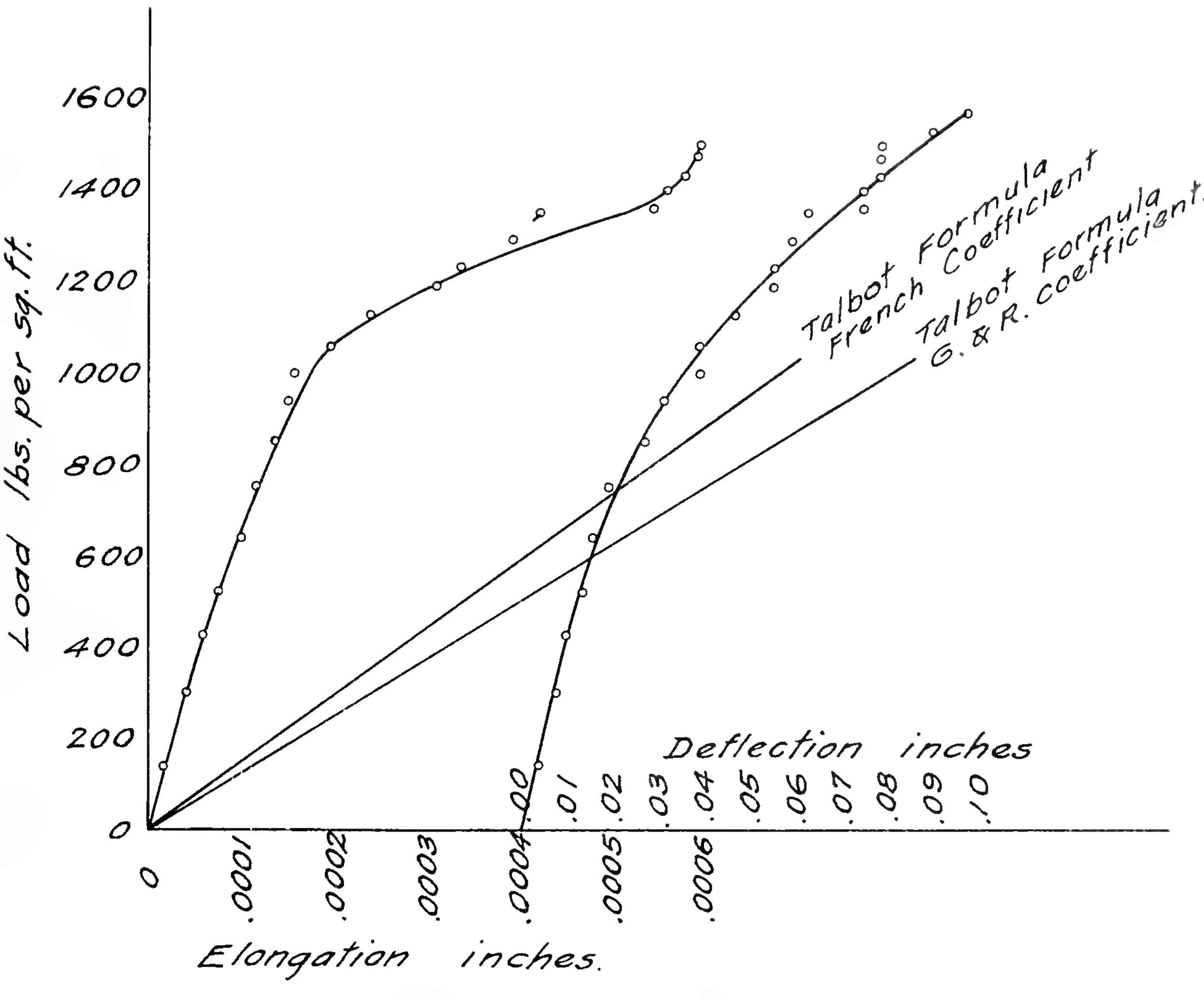

1600
1400
1200
1000
800
600
400
200
0
Load lbs. per sq. ft.
.0001
.0002
.0003
Elongation inches
Deflection inches
.01
.02
.03
.04
.05
.06
.07
.08
.09

SLAB B 2.



Load lbs. per sq. ft.
1800
1600
1400
1200
1000
800
600
400
200
0
Talbot Formula French coefficient.
Talbot Formula G. & R. coefficient.
Deflection inches.
.01 .02 .03 .04 .05 .06 .07 .08 .09 .10 .11 .12 .13 .14 .15 .16 .17 .18 .19 .20
0 .0001 .0002 .0003 .0004 .0005 .0006 .0007
Elongation inches.

SLAB C1



Load lbs. per sq. ft.
1600
1400
1200
1000
800
600
400
200
0
0
.0001
.0002
.0003
.0004
.0005
.0006
Elongation inches.
Deflection inches
.00
.01
.02
.03
.04
.05
.06
.07
.08
.09
.10
Talbot Formula
French Coefficient
Talbot Formula
G. & R. coefficient.

SLAB C2